

5.5 Years of *Fermi* LAT Flare Advocate Monitoring and Counting

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Abstract

The Fermi Flare Advocate (also known as Gamma-ray Sky Watcher) service provides for a quick look and review of the gamma-ray sky observed daily by the Fermi Large Area Telescope (LAT) through on-duty LAT Flare Advocates and high level software like the LAT Automatic Science Processing and the Fermi All-sky Variability Analysis. The FA-GSW on service provides alerts and communicates to the external scientific community potentially new gamma-ray sources, interesting transients and flares. A weekly digest containing the highlights about the variable LAT gamma-ray sky at E>100 MeV is published in the web ("Fermi Sky Blog"). Other news items are occasionally posted through the Fermi multiwavelength mailing list, Astronomer's Telegrams and Gamma-ray Coordination Network notes. From July 2008 to April 2014 almost 280 ATels and 90 GCNs have been published by the Fermi LAT Collaboration, more than 40 target of opportunity observing programs have been triggered by the LAT Collaboration and performed though the Swift satellite, and individual observing alerts have been addressed to ground-based TeV Cherenkov, optical and radio telescopes. This is helping the Fermi mission to catch opportunities offered by the variable high-energy sky, increasing the rate of simultaneous multiinstrument/telescope observations and the level of international scientific cooperation in multifrequency/multimessenger and time-domain astrophysics.



Figure 2: Outline of the all-sky map distribution, in Galactic coordinates, of the new gamma-ray sources, flares and transients found by Fermi LAT and announced through Astronomer's Telegrams (ATels). These flaring, transient, or new gammaray sources are represented with different symbols for different class (preliminary). Most of the sources reported here follow the FA-GSW service.

Different class of sources are discovered by FA-GSWs to be in high flaring state, or to pop up in the sky as new candidate gamma-ray sources not previously listed in Fermi LAT Catalogs, and new unidentified gamma-ray point sources. Among these sources, the LAT sources that were subject of ATels are represented in Fig. 2, based on a preliminary coordinate localization estimate and based on a preliminary counterpart spatial association. For particularly interesting or possible new gamma-ray sources a likelihood check of detection, significance, flux and spectral index is performed joined with the inspection of count maps, exposure maps and localization. A short daily internal report is compiled day by day and a monthly internal summary is issued in the LAT Collaboration. The Fermi sky blog (Fig. 1) is updated with a public weekly summary report. In addiction software or other technical issues are also reported during the FA shift, while improvements to the quick-look software and scripts for the reanalysis and collection of the ASP pipeline data products are periodically performed.

The rate and type of the 265 *Fermi* LAT ATels published till 2014 February are illustrated in Fig.4 and Fig. 5. More exactly such plots refer to the *Fermi* LAT ATels issued from 2008, July 24th (ATel #1628) to 2014, February 30th (ATel #5879) corresponding to about 5.5 years of Fermi survey. It is important to remark that the rate of LAT ATels continues to increase, showing that the gamma-ray sky continues to show interesting new features. The new Fermi All-sky Variability Analysis (FAVA) is now adding more useful information about the transient and variability gamma-.ray sky. The FA-GSW activity is inherently also a multi-frequency and preliminary quick-look research, starting from the spatial association of 6h/dailydetected sources, using multifrequency tools and databases (e.g. GSFC-FSSC, ASDC, NED, CDS databases) for first guess-associations, till the organization of dedicated multifrequency observing campaign on the flaring targets. The FA-GSW service is helping us in getting the best science from Fermi LAT representing also a benefit for international cooperation, completing the wide-field of view and high sensitivity, all-sky survey of Fermi LAT, an enterprise that will remain unique in the next future.



Fermi LAT Flare Advocate Service

Fermi LAT is an all-sky survey monitor. The high-energy sky is often variable and transient, therefore the FA-GSW activity is performed with continuity all the year through weekly shifts. About 70 shifters served as least one time as FA-GSW or deputy FA with weekly shifts. The FA-GSW service points out something potentially interesting and first seeds to the different LAT science groups. Basic summaries about the gamma-ray sky on six-hour and 1-day time intervals are communicated along with any relevant news to the external astrophysical community (through the LAT-MW mailing-list, Astronomer's Telegrams, ATels, GCNs, and the *Fermi* Sky Blog, see Fig.1). This allows us to promote and increase the rate of multi-frequency collaborations and observations. The role and activity of the FA-GSW is therefore twofold.

Gamma-ray Flare Advocate (FA) task

This is a role similar to the LAT burst-advocate (for GRBs). Sources exceeding 10^-6 photons/cm2/s (at E>100 MeV) are always deserving attention. This activity is addressed to release internal fast notes, ATels, ToO triggers for multi-frequency observations, and to start possible ToO multi-frequency campaigns, LAT multi-frequency papers, and on single sources in general (with the possibility to be also a contact person for a LAT source).

Gamma-ray Sky Watcher (GSW) task

All the daily and 6h ASP results are quickly inspected, looking at the detected LAT sources in the sky (Galactic and extragalactic source candidates), searching for flares and brightness trends, and for possible new candidate gamma-ray sources.



Some results

FA-GSWs discovered many new gamma-ray blazars and flares from FSRQs, BL Lac objects, radiogalaxies, gravitationally lensed blazars, high-z blazars, nearby blazars with spectral hardening (of interest for Cherenkov telescopes), short and long duty cycles in blazars, unidentified transients near and off the Galactic plane. This in addiction to flares from Galactic sources (for example Crab Nebula, microquasars), flares from Novae stars, gamma-ray emission of the quiet/flaring sun (M- and X-class flares). Many ToO following-up LAT flares were submitted to Swift, allowing a productive scientific synergy between the Fermi and Swift missions.



Figure 4: T he 265 Fermi LAT Astronomer's Telegrams (ATels) published on behalf of the LAT collaboration from 2008, July 24, to 2014, February 19 (MJD 54671-56707, i.e. in 2036 days of Fermi mission) grouped by topic and source type.



Figure 5: Statistics of the 265 Fermi LAT Astronomer's Telegrams (ATels) published on behalf of the LAT collaboration from 2008, July 24, to 2014, February 19.



Figure 6: Pictorial example of some of the FA-GSW quicklook analysis and checks performed every day and the web interfaces and pipelines used for the service (ex: ASP DRP and PGwave, FAjobs, FAVA) and hosted at the LAT **Instrument Science Operation** Center (ISOC) at SLAC (Stanford) USA.

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Some links

- fermisky.blogspot.com www-glast.stanford.edu/cgi-bin/pub_rapid



Figure 1: Left panel: the Fermi Gamma-ray Sky Blog (http://fermisky.blogspot.it), containing basic weekly summaries about the LAT sources detected on short timescales (1-day and 6-hour intervals) during the week, and compiled by the LAT Flare Advocates Gamma-ray Sky Watchers (FA-GSW). **Right panel**: the interactive catalog of the sources subject of Fermi LAT ATels at ASDC (http://www.asdc.asi.it/feratel/)

Figure 3: . The record gamma-ray flare of the flat spectrum radio quasar 3C 454.3 (Ackermann et al. 2010); the Crab nebula before and after the surprising 2013 March flare triggering a rare Fermi LAT ToO; and the X5.4-class solar flare of 2012, March 7 discovered by *Fermi* LAT. The on duty FA-GSW shifters were among the first that observed these new events in the Fermi LAT sky. These examples were NASA press

releases.

